

# ***Modeling the Effects of Nuclear Weapons in an Urban Setting***

**Radiation Countermeasures Symposium  
An AFRRI 50<sup>th</sup> Anniversary Event**

***Kyle Millage, CHP, PE  
Applied Research Associates, Inc.***

***15 June 2011***

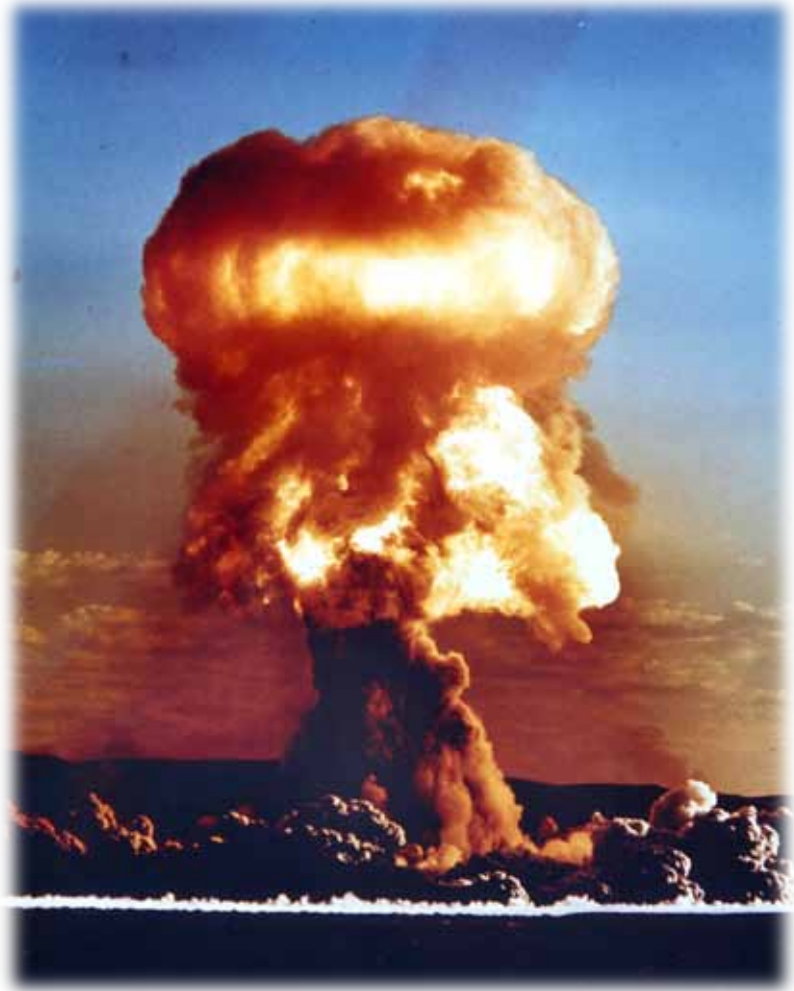
DoD DISTRIBUTION STATEMENT A APPLIES: Approved for public release; release is unlimited.





# Presentation Outline

- Setting the stage
- Prompt environments
  - Radiation
  - Blast
  - Thermal
- Urban effects
- Delayed environments
- Summary





# What Will and Won't Be Covered

- I will be talking about:
  - Environments created by a nuclear weapon detonation
  - How those environments are altered in an urban setting and how it affects our use of existing data
  - How this information can help inform the types and numbers of injuries anticipated, treatment needs and resource requirements
- I will not be talking about:
  - Specific threats or situations
  - Specific casualty estimates



# Some Questions to Consider

- What will the patient stream look like?
- Will significant numbers of patients be exposed to radiation alone?
- Will people be exposed to neutrons?
- What will the response look like?

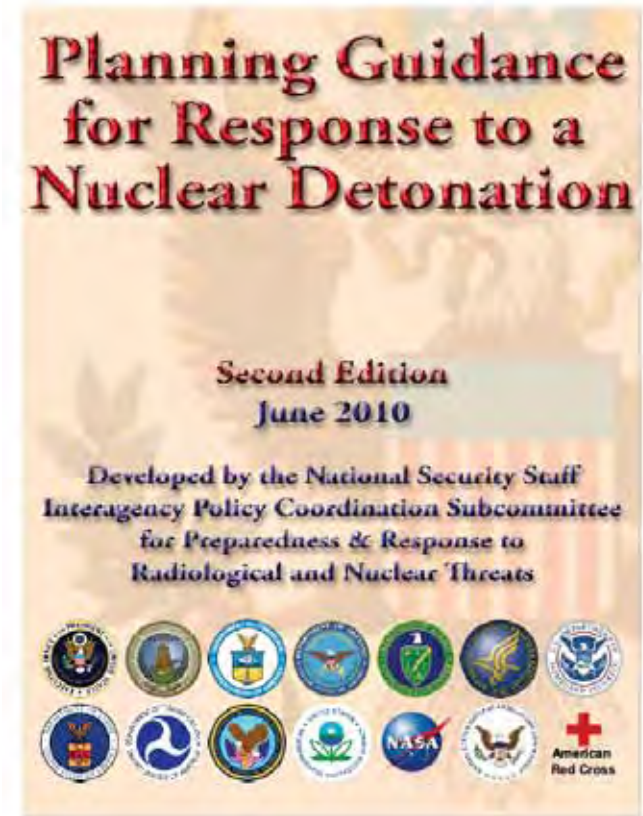




# Catastrophic, but Potentially Survivable

- One of the most catastrophic incidents that could befall the United States (US), causing enormous loss of life and property and severely damaging economic viability, is a **nuclear detonation in a US city**
- DHS National Planning Scenario (NPS) #1 (10 kT Improvised Nuclear Device (IND) Attack), is being used in national, Federal, State, and local homeland security preparedness activities

Contrary to your Civil Defense memories, a low-yield nuclear detonation in an urban setting is potentially survivable





# Nuclear Weapon Environments

Nuclear weapon environments and their associated effects depend on many factors including yield and height-of-burst (HOB). These effects include.

- Blast and Shock (air, ground, water)
- Prompt/Initial radiation
- Thermal radiation



- Cratering, ejecta and debris
- Radioactive fallout and dispersion
- Electromagnetic pulse (EMP)





# Modeling Helps us Understand Nuclear Weapon Effects

All models are wrong,  
some models are useful

George Box, 1987 (U Wisconsin  
Professor of Statistics)



UNCLASSIFIED



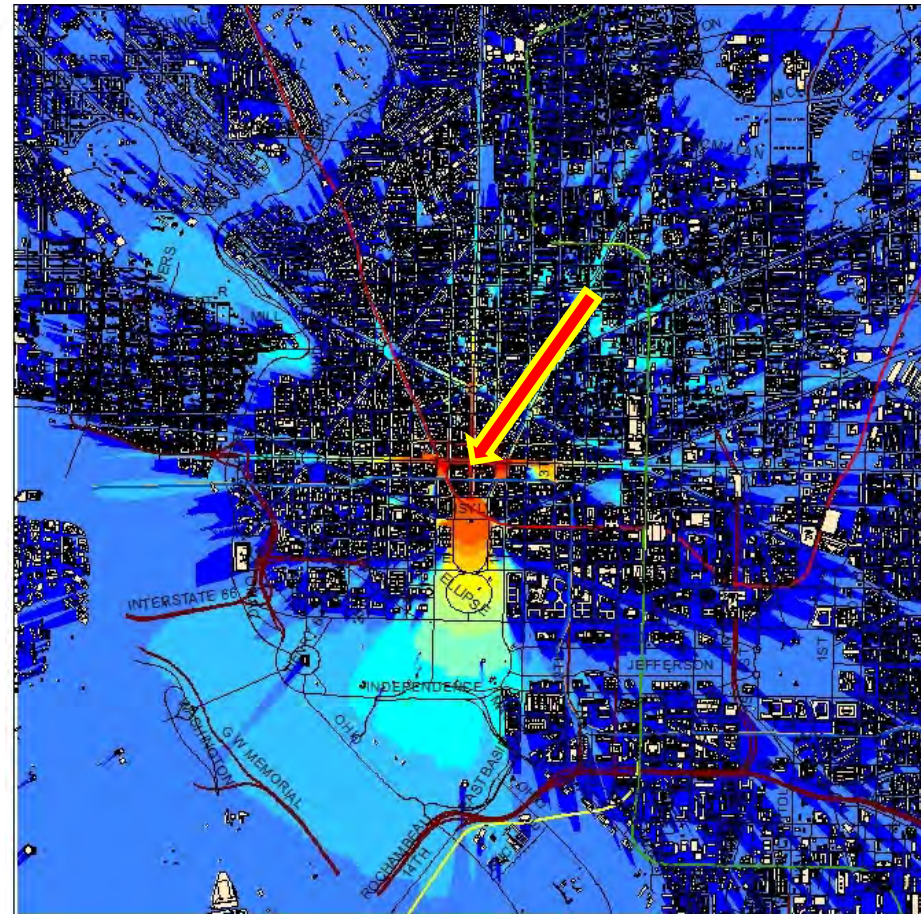
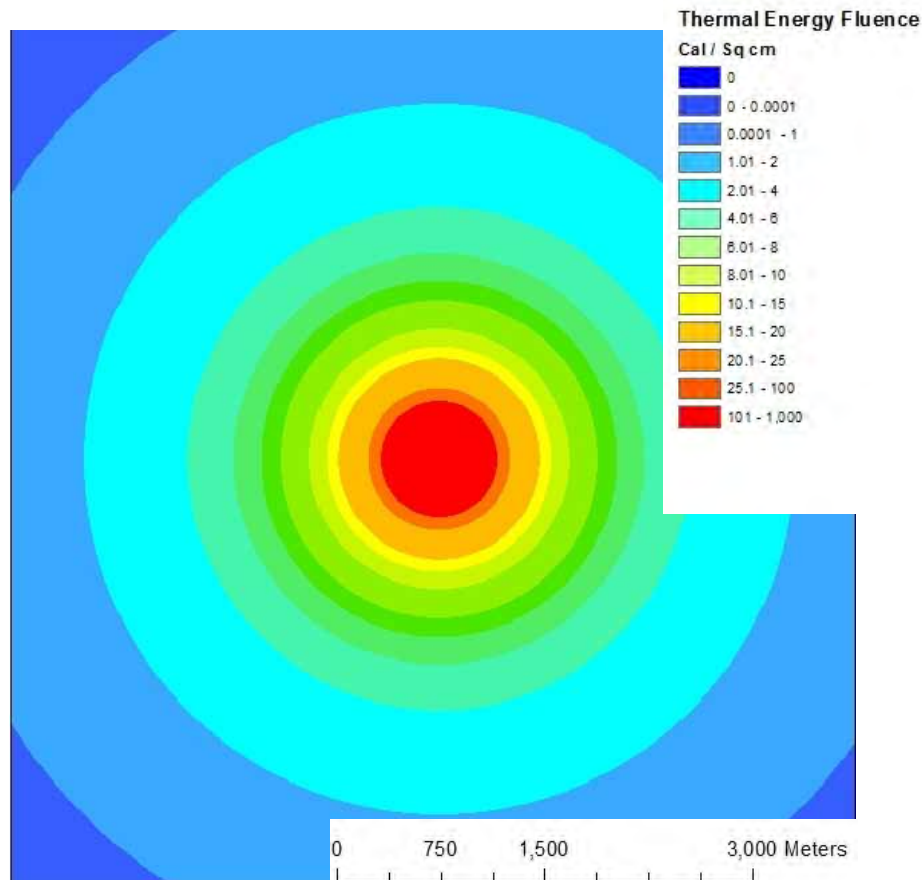
# Air Blast is Significantly Perturbed by Urban Terrain



UNCLASSIFIED



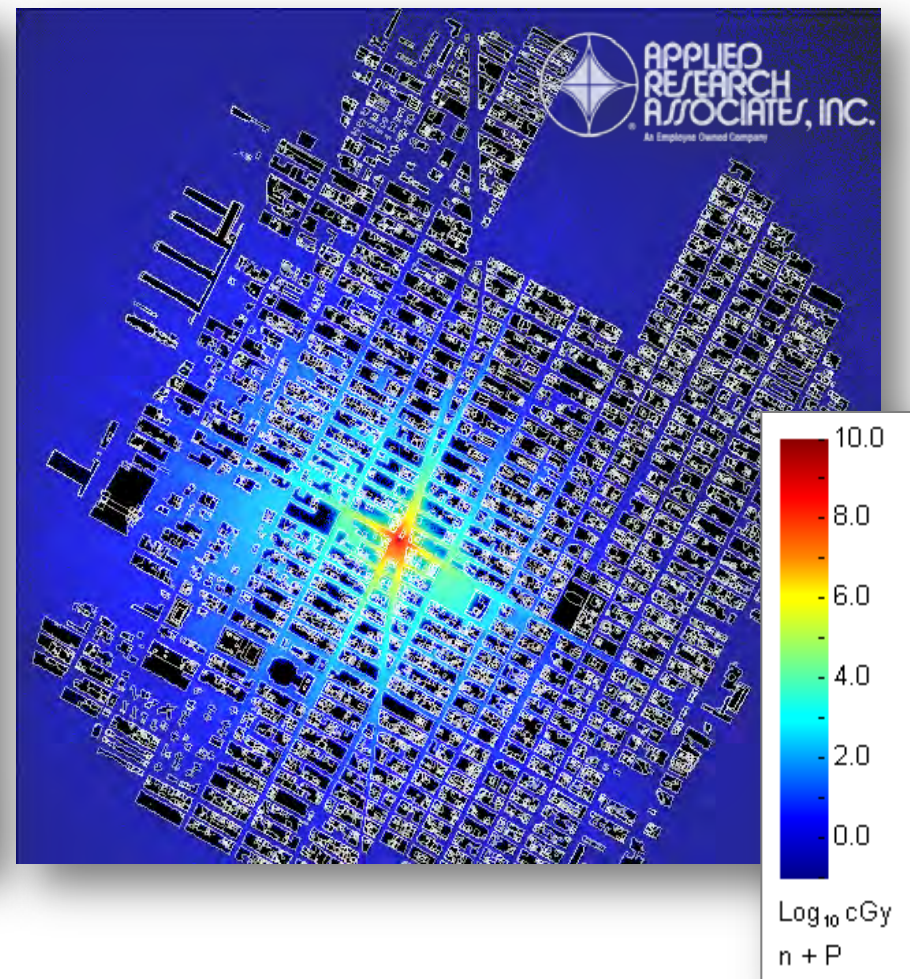
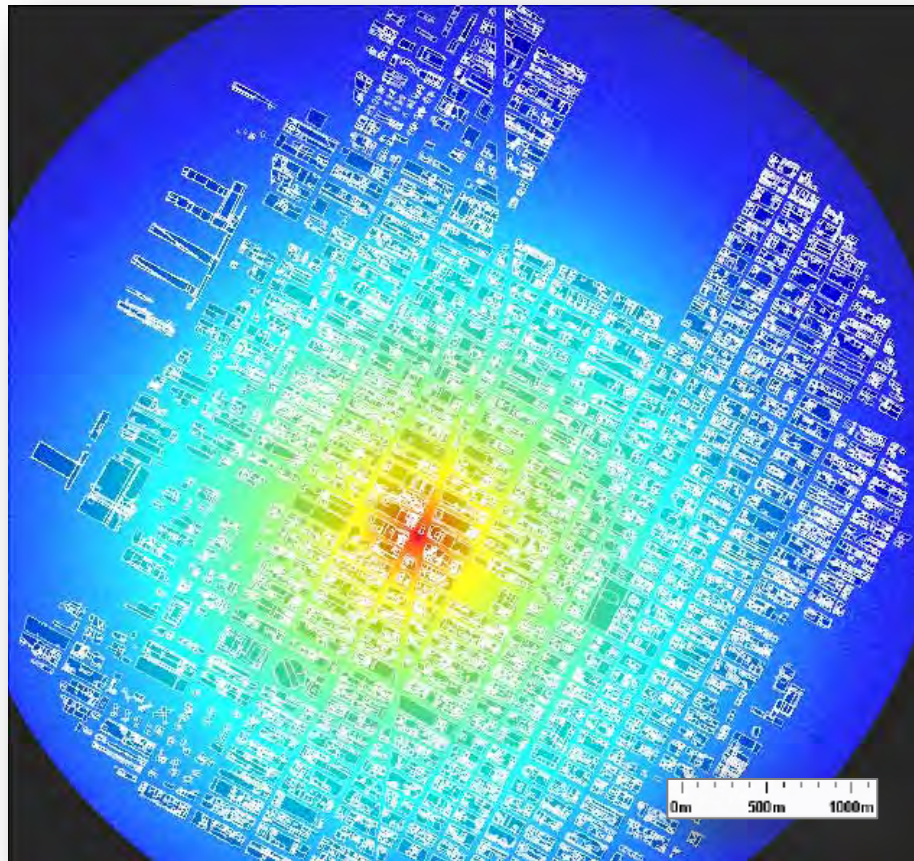
# Thermal Radiation is Also Significantly Modified in an Urban Setting





UNCLASSIFIED

# Urban Terrain Significantly Attenuates Radiation Transport



UNCLASSIFIED





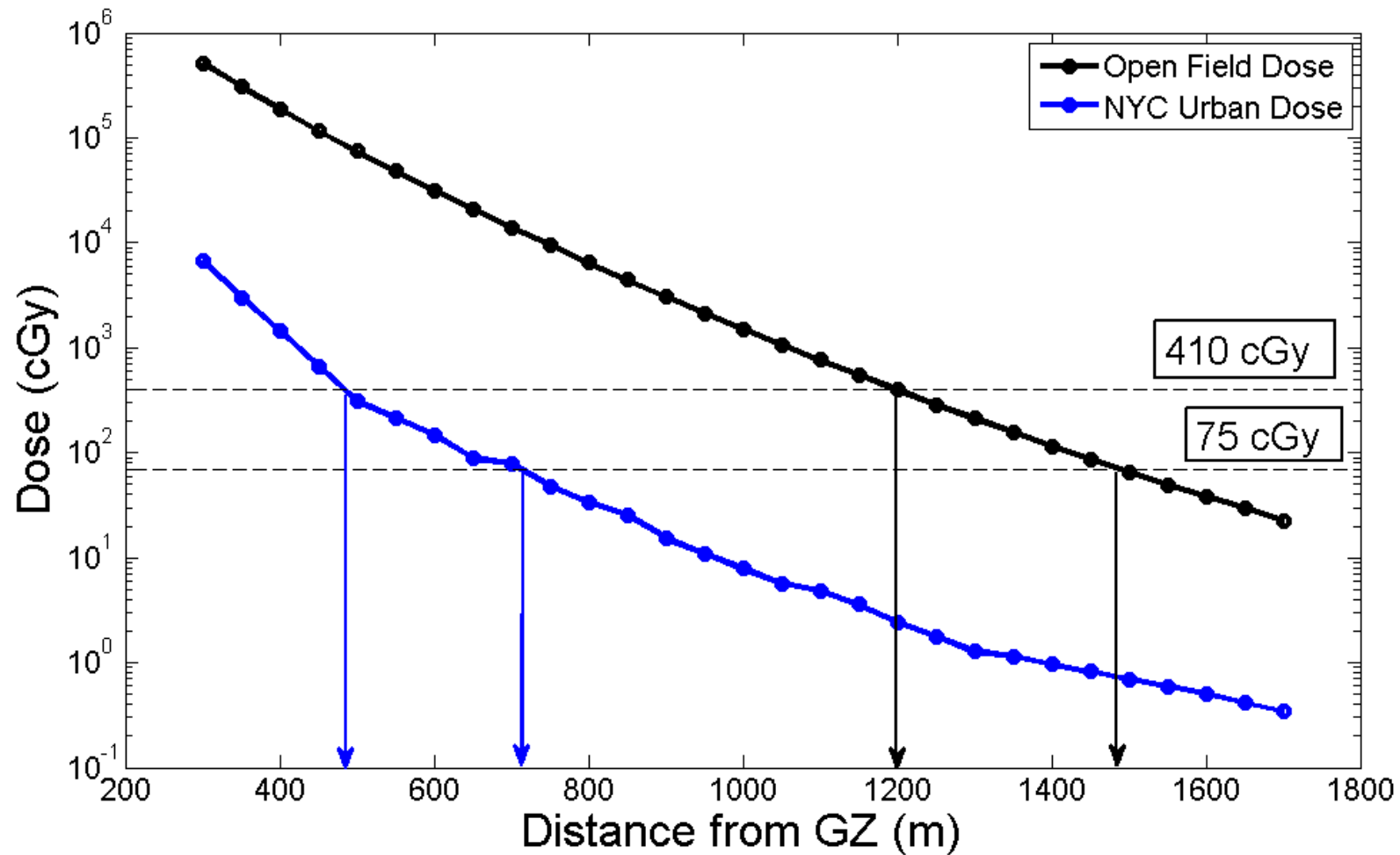
# How do These Prompt Effects Alter our Casualty Expectations?

- Classic prompt circles of blast, thermal and radiation environments in an open field will significantly over-estimate the effects in an urban setting
- Fewer fatalities than you might have expected
- May suggest there will be more casualties entering the medical system than you might have expected
- Significant blunt and penetrating trauma
- Fewer thermal burns from flash
  - Burns from secondary fires unknown
- Fewer fatalities from radiation alone

Significant numbers of sub-lethal radiation exposures, many combined with burn and trauma injury

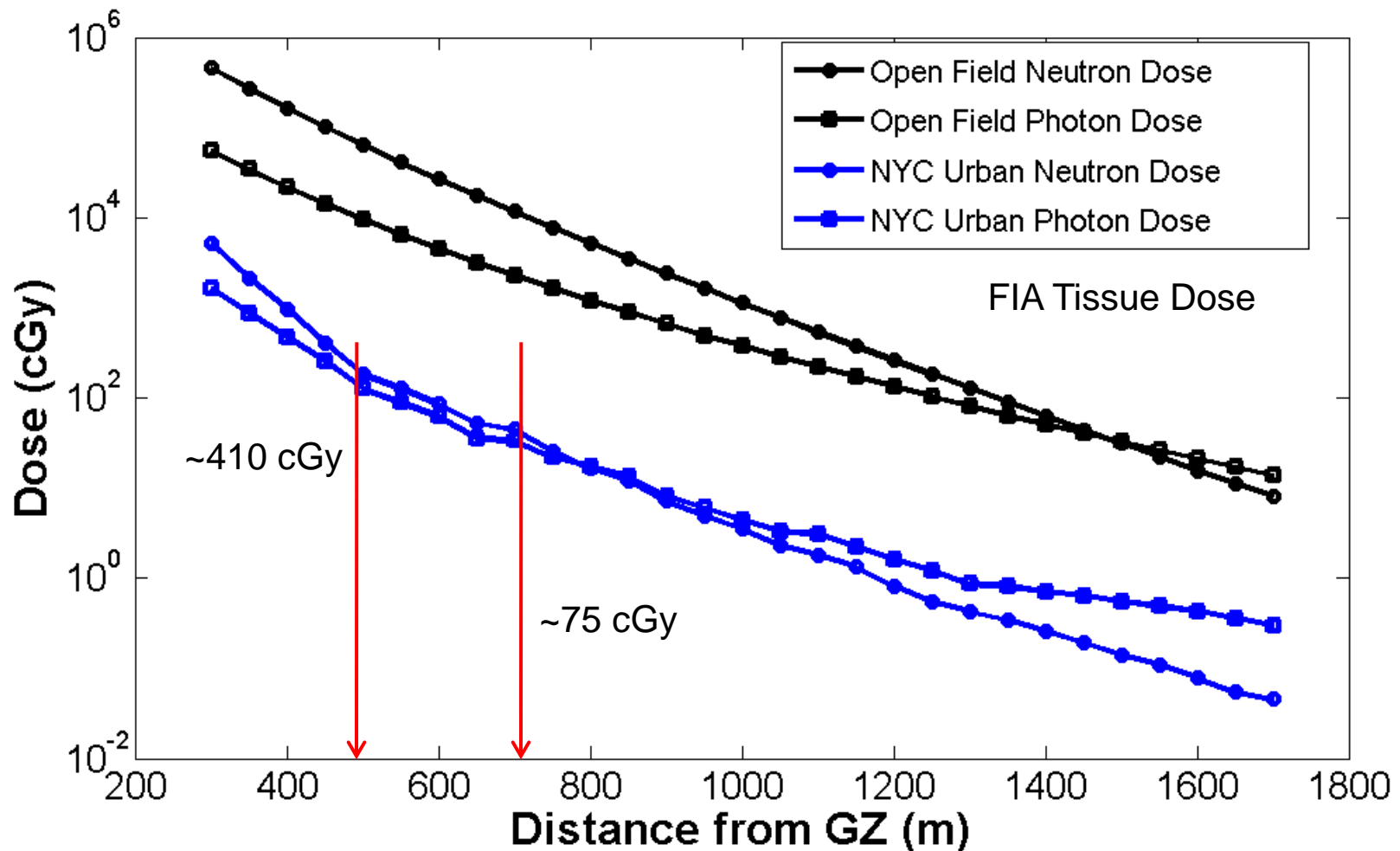


# Significant Reduction in Total Dose





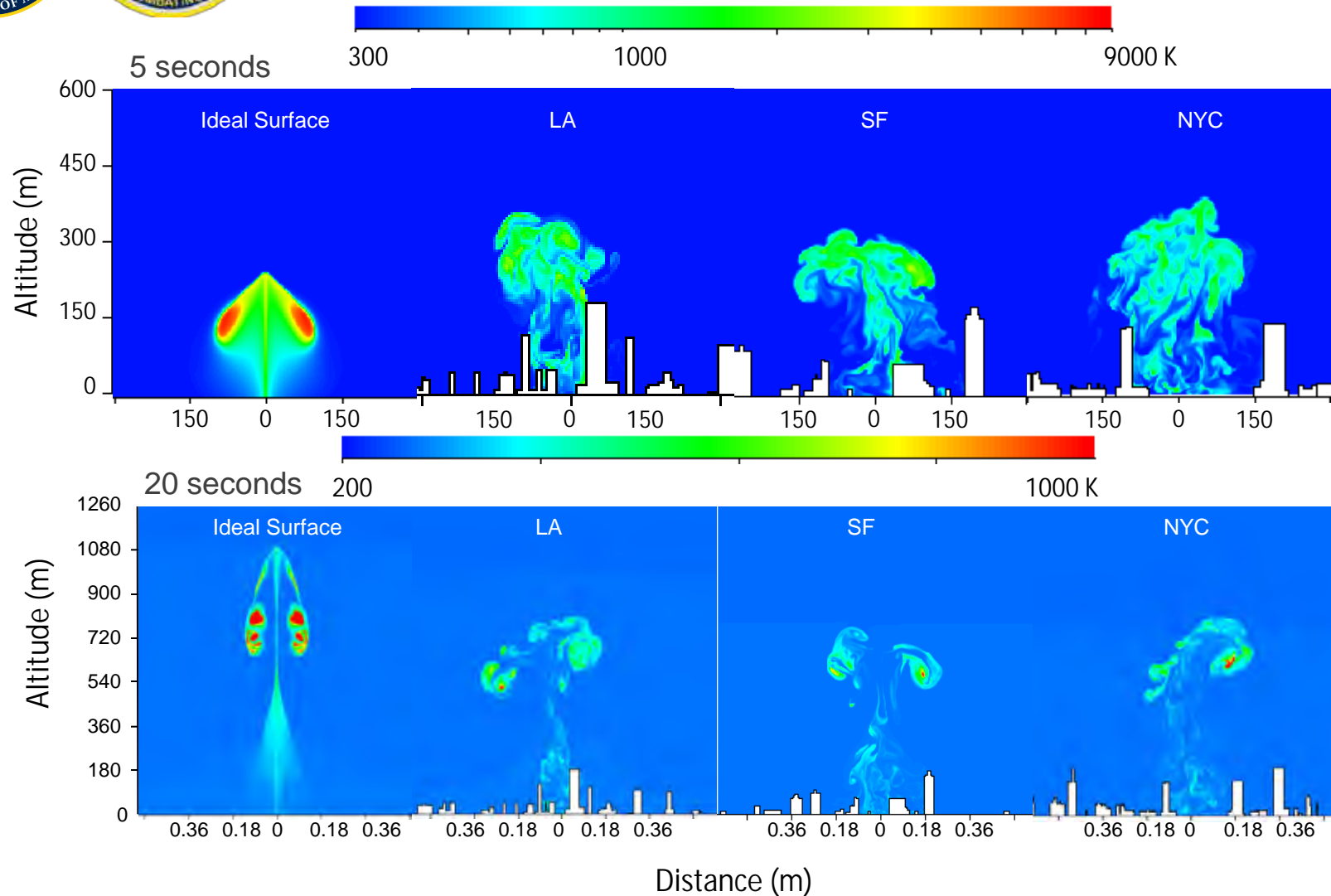
# Neutron and Photon Dose will Both Contribute in Survivable Dose Range



UNCLASSIFIED



# Radiation Fallout Will Also be Affected by Urban Terrain



UNCLASSIFIED



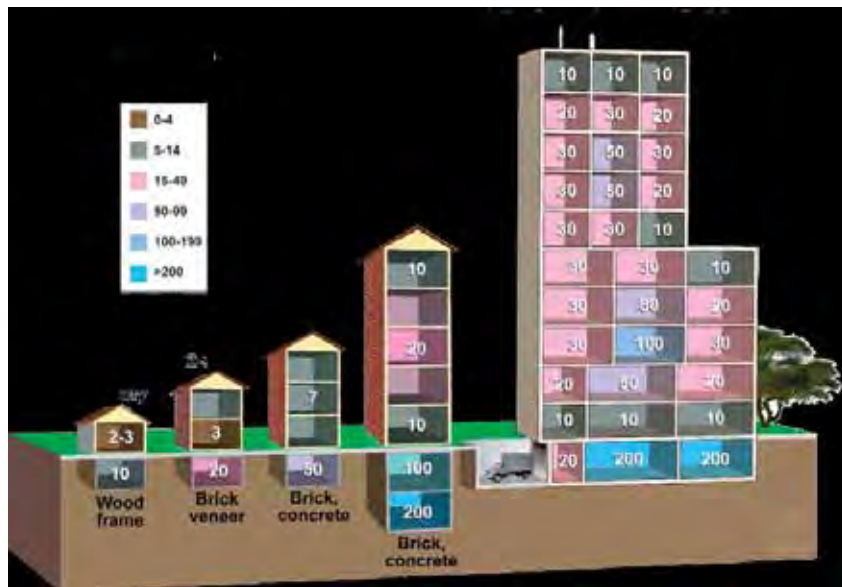
# Weather Will Dictate Fallout Patterns





# Radiation Fallout Exposure is Time Dependent

- In general, dose rate drops by a factor of 10 for every factor of 7 increase in time
- For example, the dose-rate at 7 hrs is ~10x lower than it was at 1 hr



- Studies show that absent other information, shelter-in-place in structures with Protection Factors (PFs) of 10 or more may be preferable to evacuation at early time points.

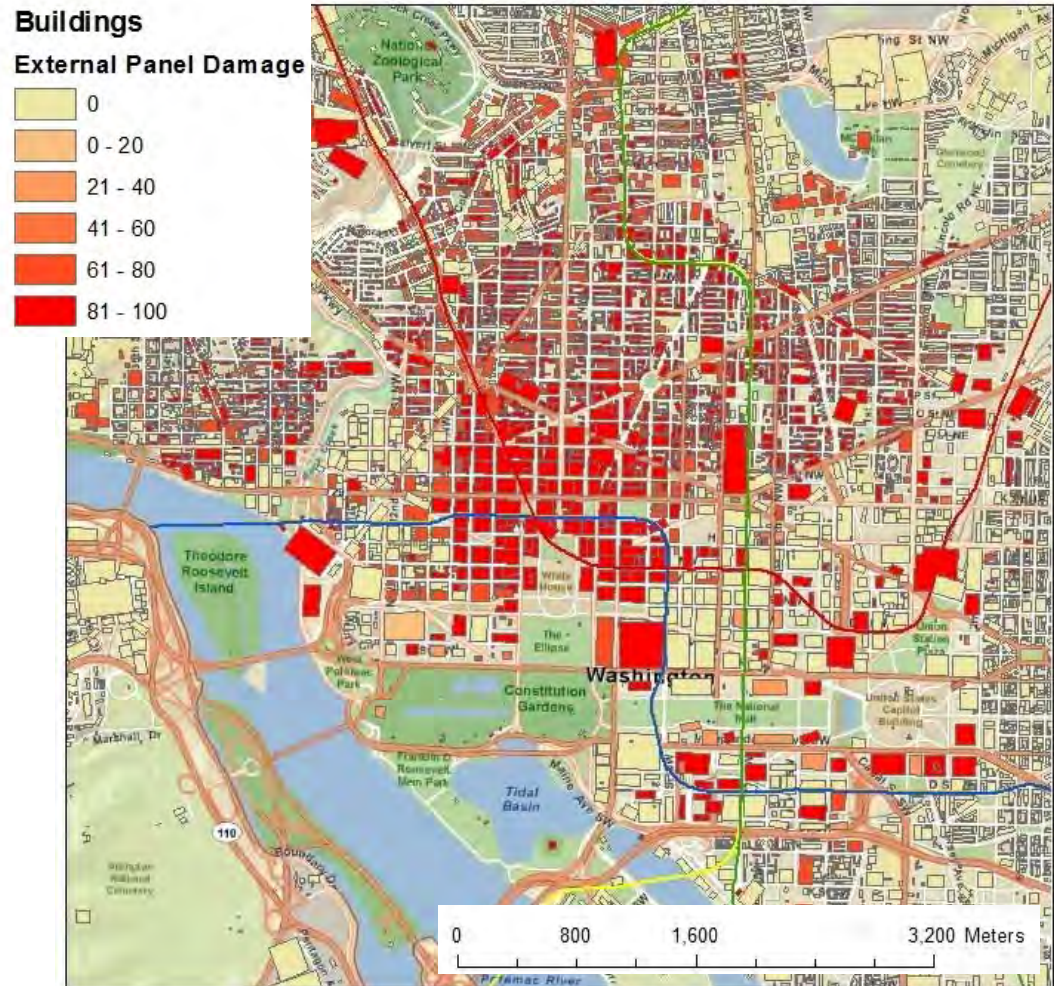


# Rubble Piles and Infrastructure Damage will Complicate Evacuations and Response Efforts



- Evacuation routes will be difficult due to infrastructure damage
- Risk associated with evacuation is more than just the risk associated with radiation exposure

Washington D.C. 10KT Ground Burst





# Other Impacts

- EMP
  - Possible impacts outside severely damaged area
  - Equipment brought into area during response will not be affected
  - Ongoing research area
- Critical infrastructure
  - Water, power, communication will be impacted
  - Blast and ground coupling may crack pipes and sever cables
  - Cascading effects may result depending on location of critical nodes
  - Ongoing research area



# Summary

- Urban terrain significantly reduces the area impacted by nuclear weapon environments
- Survivors are likely in areas where we traditionally would have expected none
  - Both photon and neutron exposures are possible
- Many survivors will have sub-lethal radiation doses
  - Many of these will also have traumatic injuries
  - Strategies for treating combined injuries will be critical for minimizing the impact of an urban IND
- Absent other information, adequate ( $PF \geq 10$ ) shelter-in-place will likely reduce fallout exposures
- Research is ongoing to better understand the urban terrain effects